

CERTIFICATE OF VERIFICATION

I, Su Hyun LEE of 648-23 Yeoksam-dong, Kangnam-ku, Seoul, Korea state that the attached document is a true and complete translation to the best of my knowledge of the Korean-English language and that the writings contained in the following pages are correct English translations of the specifications and claims of the Korean Patent Publication No. P2000-31956.

Dated this 2nd day of August 2005

Signature of translator: _____

Su Hyun LEE

[SPECIFICATION]

[TITLE OF THE INVENTION]

IN-PLAN SWITCHING MODE LCD AND METHOD OF FABRICATION
THE SAME

[BRIEF DESCRIPTION OF THE DRAWINGS]

FIG. 1 is a plan view illustrating a first substrate of a related art in-plan switching mode LCD;

FIG. 2 is a cross-sectional view taken along with the line A-A' of FIG. 1;

FIG. 3 is a plan view illustrating a first substrate of an in-plan switching mode LCD in accordance with a first preferred embodiment of the present invention;

FIG. 4 is a cross-sectional view taken along with the line B-B' of FIG. 3;

FIG. 5 is a cross-sectional view taken along with the line C-C' of FIG. 3;

FIG. 6 is a cross-sectional view taken along with the line D-D' of FIG. 3;

FIG. 7 is a plan view illustrating an in-plan switching mode LCD in accordance with a second preferred embodiment of the present invention; and

FIG. 8 is a plan view illustrating an in-plan switching mode LCD in accordance with a third preferred embodiment of the present invention.

[DETAILED DESCRIPTION OF THE INVENTION]

[OBJECT OF THE INVENTION]

[FIELD OF THE INVENTION AND DISCUSSION OF THE RELATED ART]

The invention relates to a liquid crystal display (LCD) device, and more particularly, to an in-plan switching mode liquid crystal display and fabrication method of the same device and a method of fabricating the same.

Recently, there are strong requirements in thin film transistor liquid crystal layers (TFT LCD) being widely used in portable television or notebook computer to be

[ABSTRACT OF THE DISCLOSURE]**[ABSTRACT]**

In-plan switching mode LCD includes a first substrate and a second substrate, a data electrode, common electrode and common electrode lines formed on the first substrate, a gate-insulating layer formed entirely on the first substrate over the data electrode and the common electrode and has data holes within the data electrode, a storage electrode formed on the gate-insulating layer to overlap over the common electrode lines or the common electrodes, a passivation film formed entirely on the first substrate over the storage electrode, having a hole formed at a position correspondingly to the data holes and a storage hole within the storage electrode area, a connection electrode formed on the passivation film to cover the data and storage holes formed thereon and electrically connecting between the data electrode and the storage electrode, and a liquid crystal layer formed between the first and the second substrates. In the above structure, the common electrode and the data electrode are made of the same material for the same layer, whereby a space between two electrodes are in regular and a regularity of CD is obtained so as to apply regular transverse field to the liquid crystal layer. Accordingly, a high quality image without being colored is obtained.

[TYPICAL DRAWING]

FIG 3

strongly larger, but there remains a problem of variation in contrast ratio of viewing angle in the TFT LCD. To resolve the above problem, various types of liquid crystal displays such as a twisted nematic (TN) mode liquid crystal display device in which a light compensated plate is mounted and multi-domain liquid crystal display device are introduced. However, these kinds of liquid crystal display devices could not completely overcome the problems of deterioration in the contrast ratio or variation in color.

To realize an optical viewing angle, an in-plan switching mode liquid crystal display (hereinafter referred to as 'LCD') device capable of adjusting an arrangement of a liquid crystal in accordance with an electric field parallel to a substrate of the device.

FIG. 1 and FIG. 2 are respectively a plan view and a sectional view of substrates of a related art in-plan switching mode LCD, and FIG. 2 is a cross-sectional view taken along with the line A-A' of FIG. 1. Referring to FIGS. 1 and 2, gate bus lines 1 and data bus lines 2 are formed on a first substrate 10 to divide the substrate in plurality of pixels. In drawings, only one pixel will be described for convenience. Common electrode lines 3 are arranged in parallel to the gate bus lines 1 and a thin film transistor consisted of a gate electrode 5, gate-insulating film 12, semiconductor layer 15, source electrode 6 and a drain electrode 7 is formed at a cross point where the gate bus lines 1 and the data lines 2 are intersected with each other. Within a pixel are formed a data electrode 8 and a common electrode 9 in parallel to the data bus lines 2. The data electrode 8 has a certain area where the common bus lines 3 overlap and the common electrode 9 ensuring a formation of a cumulative capacity. A passivation film 13 is additionally formed over the common electrode 9 is connected with the data electrode 8 and the gate-insulating film 12.

A color filter 21 is placed on a second substrate 20 and liquid crystal layer 22 is formed between the first and second substrates 10 and 20.

Also, although not shown in drawings, a polarizer for linearly polarizing light for penetrating a side surface of the first and second substrates 10 and 20, and in inner surface between the first and the second substrates 10 and 20 is formed an alignment film adjacent to the liquid crystal so as to determine an orientation direction of a liquid crystal.

The aforementioned in-plan switching mode operates in that a transverse electric field parallel to the first and second substrates 10 and 20 is generated between the data electrode 8 and the common electrode 9 when power is applied from an external driving circuit. Accordingly, molecular axes of liquid crystal oriented in a liquid crystal layer 22 are rotated in parallel with the first substrate along the transverse electric field, to thereby control light transmissivity of the liquid crystal layer 22. Herein, since grey scale is driven with a state the liquid crystal molecule is parallel to the substrate, the difference in light transmissivity depended upon the viewing angle is reduced.

However, in the related art in-plan switching mode liquid LCD, the data electrode 8 and the common electrode 9, for applying electric field to the liquid crystal layer, are formed at different layers, respectively, that an orientation of electrodes are disturbed, when the common bus lines overlap the common electrode, during the formation of the gate, source and the drain electrodes, which results in an irregularity of distance between the data electrode and the common electrode. Hence, the difference in the distance between such electrodes renders different electric fields which are to be applied to the liquid crystal between the electrodes, so that the orientation of the liquid crystal is failed to be yielded in a preferred condition.

Also, with the above LCD structure, as the size of the screen gets larger, the more irregularity in CD is found, which will make the distance between the data and the common electrode irregular, for creating black spots on a screen.

[TECHNICAL TASKS TO BE ACHIEVED BY THE INVENTION]

Accordingly, the present invention is directed to an in-plan switching mode liquid crystal display and a method for manufacturing the same that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide an in-plan switching mode liquid crystal display in which a data electrode and a common electrode are composed of same material and formed at the same layer, which enhances regularity in CD, thereby preventing any black spots on a screen but yielding high quality images.

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, an in-plan switching mode LCD includes a first substrate and a second substrate, a data electrode, common electrode and common electrode lines all being formed on the first substrate, a gate-insulating layer formed entirely on the first substrate over the data electrode and the common electrode and has data holes formed within the data electrode, a storage electrode formed on the gate-insulating layer to overlap over the common electrode lines or the common electrodes, a passivation film formed entirely on the first substrate over the storage electrode, having a hole formed at the same position corresponding to the data holes and a storage hole formed within the storage electrode area, a connection electrode formed on the passivation film to cover the data and storage holes formed thereon and electrically connecting between the data electrode and the storage electrode, and a liquid crystal layer formed between the first and the second substrates.

It is preferable that the common electrode and the data electrode are selected from a group consisting of aluminum (Al), chromium (Cr), tantalum (Ta), aluminum alloy (Al alloy) or indium tin oxide (ITO).

It is preferable that the connective electrode is communicated with the data electrode through a data hole and with the storage electrode through a storage hole, and it is composed of a transparent material such as an indium tin oxide (ITO).

In another aspect of the present invention, there is provided a method of fabricating an in-plan switching mode LCD device including steps of: forming a first and a second substrate; forming common bus lines, common electrodes and data electrode by patterning the first substrate on which a transparent metallic film is deposited; forming a first gate-insulating layer thereover; depositing another transparent metallic film on the first substrate on which the gate-insulating layer is applied, patterning the same and forming a storage electrode thereafter; forming a second gate-insulating layer thereover; etching partially the storage electrode area of the second gate-insulating layer to form the storage hole and thereafter etching partially the data electrodes of the first and the second gate-insulating layers to form data holes; depositing electricity conductive material on the second gate-insulating layer, patterning the same to form a connective electrode for covering the data holes and the storage holes; and forming a liquid crystal layer by injecting liquid crystal between the first and the second substrates.

It is preferable that the connective electrode is composed of a transparent conductive material such as an indium tin oxide (ITO).

In a second embodiment of the present invention, an in-plan switching mode LCD includes a first substrate and a second substrate, a data electrode, common electrode and common electrode lines all being formed on the first substrate, a first gate-insulating layer formed entirely on the first substrate over the data electrode and the common electrode and has data holes formed within the data electrode, a second gate-insulating layer formed over the first gate-insulating layer and has a hole at the

same position as the data hole, a connective electrode formed to partially overlap the common electrode and the common bus lines and formed on the second gate-insulating layer so as to cover the data hole, and a liquid crystal layer sandwiched between the first and the second substrates.

In a third embodiment of the present invention, an in-plan switching mode LCD includes a first substrate and a second substrate, a data electrode, common electrode and common electrode lines all being formed on the first substrate, a first gate-insulating layer formed entirely on the first substrate over the data electrode and the common electrode and has data holes formed within the data electrode, a storage electrode formed on the gate-insulating layer to overlap over the common electrode lines or the common electrodes and covers the data holes to be connected to the data electrode, and a liquid crystal layer sandwiched between the first and the second substrates.

In the above structure, the common electrode and the data electrode are made of the same material for the same layer, whereby two electrodes are spaced apart in a regular distance, so as to obtain a regularity of CD and to apply regular transverse field to the liquid crystal layer. Accordingly, a high quality image without being colored is obtained.

[PREFERRED EMBODIMENTS OF THE INVENTION]

Referenced will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

FIG. 3 is a plan view illustrating a first substrate of an in-plan switching mode LCD in accordance with a first preferred embodiment of the present invention, FIG. 4 is a cross-sectional view taken along with the line B-B' of FIG. 3, FIG. 5 is a cross-sectional view taken along with the line C-C' of FIG. 3 and FIG. 6 is a cross-sectional view taken along with the line D-D' of FIG. 3.

As shown in the above figures, gate bus lines 101 and data bus lines 102 are formed on a first substrate 110 to divide the substrate in plurality of pixels. However, in the enclosed drawing, only one pixel is described for convenience. Common electrode lines 103 are arranged in parallel with the gate bus lines 101 and a thin film transistor consisted of a gate electrode 105, gate-insulating film 112, semiconductor layer 115, source electrode 106 and a drain electrode 107 are formed at a cross point where the gate bus lines 101 and the data lines 102 are intersected with each other. Within a pixel area, a common electrode 109 which is integrally formed with the common bus lines 103 is placed parallel with the gate bus lines 101 and includes a cumulative capacity 109' for receiving cumulative capacity disposed on one side opposite to where the common bus lines 103 are connected. The data electrode 108 is formed at the same layer as the common electrode 109 in parallel to each other, which is different from the related art. And, both ends of the data electrode 108 are taken apart from common electrode 109 and the common bus lines 103, respectively, in a prescribed distance. The gate-insulating layer 112 is formed in such a manner that it covers entirely over the gate bus lines 101, common bus lines 103, gate electrode 105, data electrode 108 and common electrode 109.

As shown in FIGS. 3 and 6, a first storage electrode 131 formed on the gate-insulating layer 112 is fabricated with the drain electrode 107 as one unit and partially overlaps a cumulative capacity 109' of the common electrode 109 with disposing the gate-insulating layer 112 therebetween, so as to obtain the cumulative capacity.

Also, a second storage electrode 132 formed at the same layer as a first storage electrode 131 is fabricated to overlap the common bus lines 103, so as to obtain the cumulative capacity.

A passivation film 113 is formed entirely on the first substrate 110 over the drain

electrode 107, the source electrode 106 and the first and second storage electrodes 131 and 132. As shown in FIGS. 3 and 6, a first storage hole 141 is formed within an area of the first storage electrode 131 of the passivation film 113, a second storage hole 142 within an area of the second electrode 132. As shown in FIGS. 3 and 5, a first data hole 143, a second data hole 144, a third data hole 145 and a fourth data hole 146 is formed within an area of the data electrode 108 of the passivation film 113. On the upper surface of the passivation film 113 are formed a first and second connective electrodes 151 and 152, which are composed of a conductive material, to cover both the data hole and the storage hole. Hence, the first connective electrode 151 is in communication with the first storage electrode 131 through the first storage hole 141, and the second connective electrode 152 is in communication with the second storage electrode 132 through the second storage hole 142. Also, the first connective electrode 151 is communicated with the data electrode 108 through the first and the second data holes 143 and 144, and the second connective electrode 152 is in communication with the data electrode 108 through the third and the fourth data holes 145 and 146. Hence, the first connective electrode 151 serves as a linker connecting the first storage electrode 131 to the data electrode 108, and the second connective electrode 152 serves as a linker connecting the second electrode 132 to the data electrode 108. The first and second connective electrodes 151 and 152 are selected from a group composed of a metallic conductive material, or else, an indium tin oxide (ITO), which is a transparent material, so as to make an IOP(ITO on passivation film) structure. Also, the connective electrodes 151 and 152 are capable of blocking an electric field formed at the area between the data electrode 108 and the common electrode 109 and therefore it is preferable not to form any connective electrodes between the data electrode 108 and the common electrode 109.

In the meantime, a color filter layer 29 is formed on the second substrate 120, and a liquid crystal layer 122 is formed between the first and the second substrates 110 and 120.

Although it is not shown in the drawings, inside an inner surface of the liquid crystal layer 122 of the first and the second substrates 110 and 120, there is formed an alignment film are adjacent to the crystal layer 122, for determining the orientation direction of the liquid crystal.

To fabricate the aforementioned in-plan switching mode LCD device, at first, the first substrate 110 is deposited with a conductive material, such as aluminum (Al), molybdenum (Mo), tantalum (Ta), aluminum alloy (Al alloy) or indium tin oxide (ITO) by sputtering, which then is patterned by photolithography to form the gate electrode 105, gate bus lines 102, common electrode 109 and data electrode 108.

Thereafter, an inorganic film composed of either silicon nitride (SiN_x) or silicon oxide (SiO_x) is deposited by plasma chemical vapor deposition (CVD) to form the gate-insulating layer 112.

Next, amorphous silicon is deposited thereon by CVD and etched thereafter to form a semiconductor layer, and although not shown in the drawings, n⁺ a-Si film is deposited in the source and drain electrode area of the semiconductor layer to form an ohmic contact layer. At this time, the gate-insulating layer 112, the semiconductor layer and the n⁺ a-Si film could be deposited in sequential order and patterned at the same time.

Thereafter, a metal material selected from a group consisted of Al, Cr, Ti and Al alloy are is deposited thereon by sputtering, so as to form the source electrode 106, the drain electrode 106 and the storage electrodes 131 and 132.

Next, an inorganic film composed of silicon nitride (SiN_x) or silicon oxide

(SiO_x) or an organic film composed of photosensitive acrylic resin film or a benzocyclobutene (BCB) film may be deposited entirely over the first substrate 110 to form the passivation film 113, and then a certain part of the passivation film 113 and the gate-insulating film 112 within the area of the first, the second, the third and the fourth holes 143, 144, 145 and 146 is etched, and a certain part of the passivation film 113 within the area of the first and the second storage holes 141 and 142 is etched. At this time, although not shown in the drawings, gate pad holes are formed by etching the passivation film 113 and the gate-insulating layer 112 within a gate pad area that is connected to a gate driving circuit of the gate bus lines 101, and data pad holes are formed by etching the passivation film 113 within a data pad area which is connected to a data driving circuit of the data bus lines 102.

Next, in addition, a transparent material such as an ITO is deposited and patterned thereafter to form the connective electrodes 131 and 132. And although not shown in the drawings, to enhance the electrical connection between the gate and the data bus lines 101 and 102 and each of the driving circuits, the ITO material is additionally deposited within the pad area. Herein, it is preferable that the connective electrodes 131 and the 132 are selected from the metal group composed of Al, Mo, Ta and Al alloy.

Then, although not shown in the drawings, a photosensitive polyimide film is doped thereon, which then is rubbed to form a first alignment film. The first alignment film is composed of a photo alignment material such as siloxane or cellulosinamate. In such as case, the orientation direction of the liquid crystals is arranged by projecting ultra violet rays rather than by rubbing.

A color filter layer 121 is formed on the second substrate 120, and thereon, a second alignment film (not shown) is formed in the same manner as that of the first

alignment film.

Subsequently, sealing material is printed on upper surfaces of the first and the second substrates 110 and 120 to be appended with each other. And then, liquid crystal molecules are injected between the substrates, thereby forming a liquid crystal layer 122.

In the present embodiment, since the data electrodes 108 and the common electrodes 109 are formed at the same layer with the same material having regular distances therebetween, power strength of an electric field applied to the liquid crystal layer 122 are dispersed regularly, thereby enhancing regularity of CD.

FIG. 7 is a plan view illustrating a in-plan switching mode LCD in accordance with a second preferred embodiment of the present invention. The second embodiment is almost the same as the first embodiment except for the following characters, and where possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts and the explanation therefore will be omitted. Referring to FIG. 7, instead of forming the storage electrode as illustrated in the first embodiment, a third connective electrode 133 overlaps the common bus lines 134 and a fourth connective electrode 134 overlaps the cumulative capacity 109' of the common electrode 109. In the present embodiment, the connective electrodes 133 and 134 not only serve as to connect the drain electrode 107 to data electrode 108 but also plays a role of the storage electrode which was illustrates in the first embodiment. In this instance, the passivation film 113 within an area of the drain electrode 107 is etched, without forming the first and the second storage holes 141 and 142 as the first embodiment, to form the contact hole 147, and the third electrode 133 is connected to the drain electrode 107 through the contact hole 147.

FIG. 8 is a plan view illustrating a transverse electric field type LCD in accordance with a third preferred embodiment of the present invention. In the third

embodiment, instead of forming a connective electrode as in the first embodiment, part of each of a fifth and a sixth storage electrodes 135 and 136 overlap the data electrode 108, and the data electrode 108 is connected to the storage electrodes 135 and 136 through a fifth, sixth, seventh and eighth data holes 148, 149, 110 and 111 formed on the gate-insulating film 112 within the area where the storage electrodes 135 and 136 overlap the data electrode 108. The storage electrodes 135 and 136 are made of electrically conductive materials and preferably selected from a metallic group composed of Al, Mo, Ta and Al alloy. Since the connective electrode is not established, there is not formed any holes on the protective film 113. Also, if the storage electrodes 135 and 136 are composed of the metallic substance, although not shown in the drawings, a redundancy electrode composed of a transparent material such as ITO in the data-hole areas 148, 149, 160 and 161 to make sure the electric connection between the storage electrodes 135 and 136 and the data electrode 108. The redundancy electrode is sandwiched between the storage electrodes 135 and 136 within the data hole areas 148, 149, 160 and 161 and the gate-insulating layer 113 or on the storage electrodes 135 and 136 within the data-hole areas 148, 149, 160 and 161. The present embodiment is almost the same as the first embodiment except for the above-mentioned characteristics.

[EFFECT OF THE INVENTION]

In the present invention, since data electrodes and common electrodes are formed at the same layer with the same material to make the distances therebetween are in a regular from to render power strength of an electric field applied to the liquid crystal layer regular, thereby enhancing regularity of CD.

What is Claimed is:

1. An in-plan switching mode LCD comprising:

a first substrate and a second substrate;

a data electrode, common electrode and common electrode lines all being formed on the first substrate;

a first gate-insulating layer formed entirely on the first substrate over the data electrode and the common electrode and has data holes formed within the data electrode;

a storage electrode formed on the gate-insulating layer to overlap over the common electrode lines or the common electrodes;

a second gate-insulating layer formed entirely on the first substrate over the storage electrode, having a hole formed at the same position corresponding to the data holes and a storage hole formed within the storage electrode area;

a connection electrode formed on the passivation film to cover the data and storage holes formed thereon and electrically connecting between the data electrode and the storage electrode; and,

a liquid crystal layer formed between the first and the second substrates.

2. The device of claim 1, wherein the data electrode and the common electrode are made of same material to each other.

3. The device of claim 1, wherein distances between the data electrodes and the common electrodes are in regular.

4. The device of claim 1, wherein the connective electrode is composed of an indium tin oxide (ITO).

5. The device of claim 1, wherein at least one of the storage electrodes is overlapped with the common bus lines, and at least one of the storage electrodes except for the one being overlapped with the common bus lines is formed integrally with the drain electrode to be partially overlapped with the common electrode.

6. An in-plan switching mode LCD comprising:

a first substrate and a second substrate;

a data electrode, common electrode and common electrode lines all being formed on the first substrate;

a first gate-insulating layer formed entirely on the first substrate over the data electrode and the common electrode and has data holes formed within the data electrode;

a second gate-insulating layer formed over the first gate-insulating layer and has a hole at the same position of the data hole;

a connective electrode formed to partially overlap the common electrode and the common bus lines and formed on the second gate-insulating layer so as to cover the data hole; and,

a liquid crystal layer sandwiched between the first and the second substrates.

7. The device of claim 6, wherein the data electrode and the common electrode are made of same material to each other.

8. The device of claim 6, further comprising:

a thin film transistor including a drain electrode formed between the first and the second gate-insulating layer; and

contact holes formed on the second gate-insulating layer within the drain electrode;

wherein,

the connective electrode is formed to cover the contact holes to be connected to the drain electrode.

9. The device of claim 6, wherein the connective electrode is composed of a transparent material such as an indium tin oxide (ITO).

10. An in-plan switching mode LCD comprising:

a first substrate and a second substrate;

a data electrode, common electrode and common electrode lines all being formed on the first substrate;

a first gate-insulating layer formed entirely on the first substrate over the data electrode and the common electrode and has data holes formed within the data electrode;

a storage electrode formed on the gate-insulating layer to overlap over the common electrode lines or the common electrodes and covers the data holes to be connected to the data electrode; and,

a liquid crystal layer sandwiched between the first and the second substrates.

11. The device of claim 10, wherein the data electrode and the common electrode

are made of same material to each other.

12. The device of claim 10, further comprising:

a thin film transistor including a drain electrode formed between the first and the second gate-insulating layer; and

a set of storage electrodes;

wherein,

one of the storage electrodes is overlapped with the common bus lines, and the other one is formed integrally with the drain electrode to be partially overlapped with the common electrode.

13. The device of claim 10, wherein a redundancy electrode is formed within the data-hole area.

14. The device of claim 13, wherein the redundancy electrode is composed of an indium tin oxide (ITO).

15. The device of claim 13, wherein the redundancy electrode is sandwiched between the first gate-insulating layer and the storage electrode.

16. The device of claim 13, wherein the redundancy electrode is formed over the storage electrode.

17. An in-plan switching mode liquid crystal display device generating two-directional electric fields almost in parallel to a surface of a substrate based on data

electrodes and common electrodes formed on the substrate, wherein the data electrodes and the common electrodes are composed of the same material.

18. The device of claim 17, wherein distances between the data electrodes and the common electrodes are in regular.

19. A method of fabricating an in-plan switching mode liquid crystal display device comprising steps of:

forming a first and a second substrate;

forming common bus lines, common electrodes and data electrode by patterning the first substrate on which a transparent metallic film is deposited;

forming a first gate-insulating layer thereon;

depositing another transparent metallic film on the first substrate on which the gate-insulating layer is applied, patterning the same and forming a storage electrode thereafter;

forming a second gate-insulating layer thereon;

etching partially the storage electrode area of the second gate-insulating layer to form the storage hole and thereafter etching partially the data electrodes of the first and the second gate-insulating layers, to form data holes;

depositing electricity conductive material on the second gate-insulating layer, patterning the same to form a connective electrode, for covering the data holes and the storage holes; and

forming a liquid crystal layer by injecting liquid crystal between the first and the second substrates.

20. The device of claim 19, wherein the electricity conductive material is an indium tin oxide (ITO).

DRAWING

FIG. 1

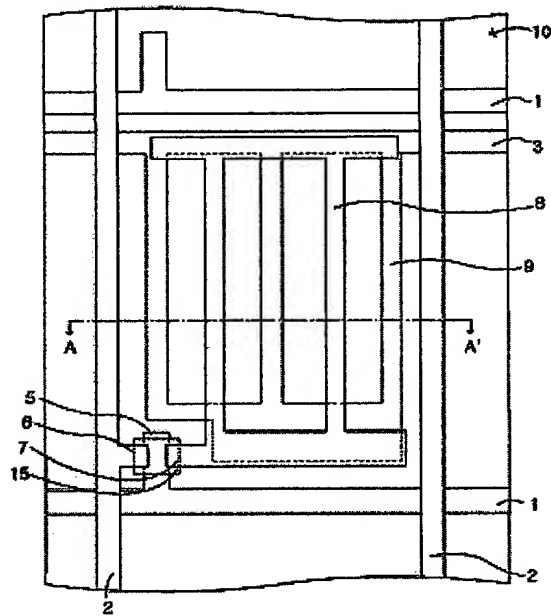


FIG. 2

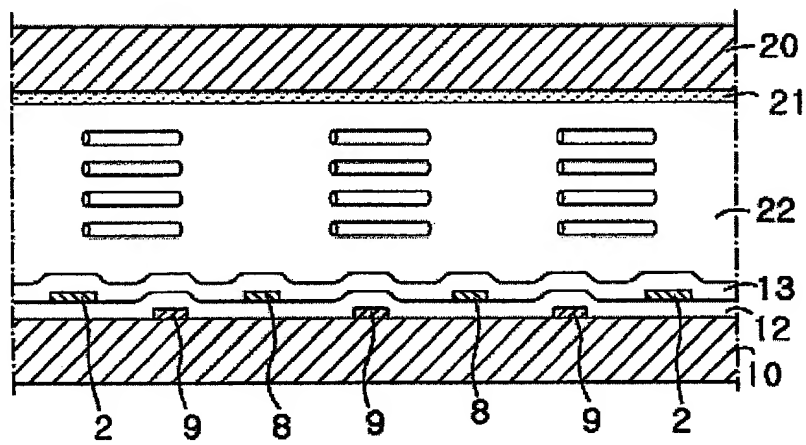


FIG 3

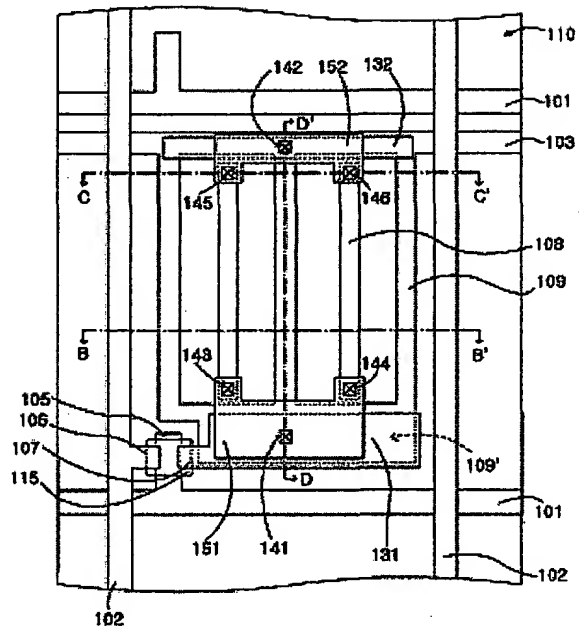


FIG 4

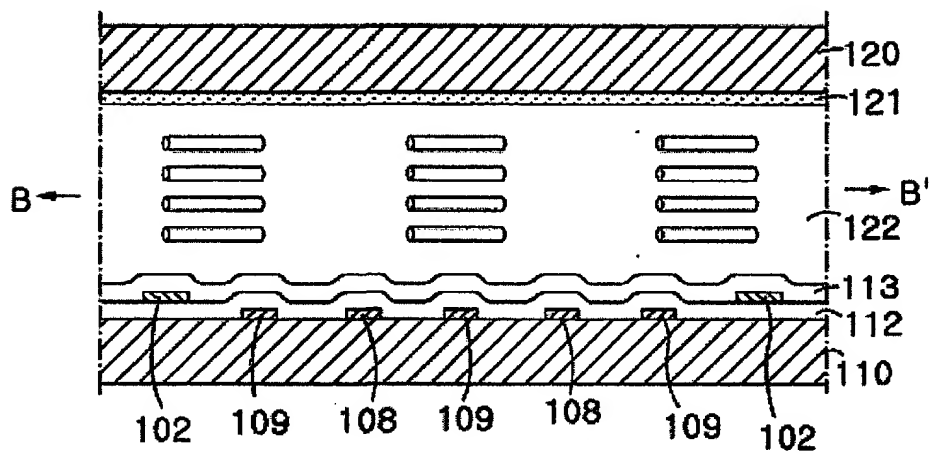


FIG. 5

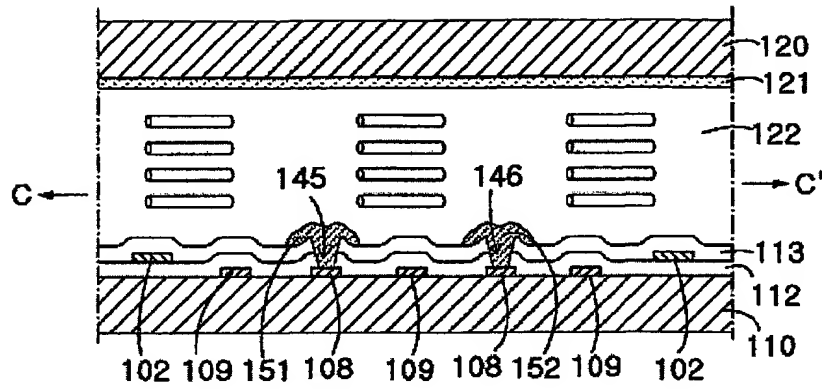


FIG. 6

